of the opposed surfaces to be a few square centimetres. To fix the ideas, I shall suppose it to be exactly thirty square centimetres. If my sense of force were sufficiently metrical I should find that the work done by the attraction of the rigidified pieces of water in pulling my two hands together was just about four and a half centimetre-grammes. The force to do this work, if it had been uniform throughout the space of fifty micro-millimetres (five-millionths of a centimetre) must have been nine hundred thousand grammes weight, that is to say, nine-tenths of a ton. But in reality it is done by a force increasing from something very small at the distance of fifty micro-millimetres to some unknown greatest amount. It may reach a maximum before absolute contact, and then begin to diminish, or it may increase and increase up to contact, we cannot tell which. Whatever may be the law of variation of the force, it is certain that throughout a small part of the distance it is considerably more than one ton. It is possible that it is enormously more than one ton, to make up the ascertained amount of

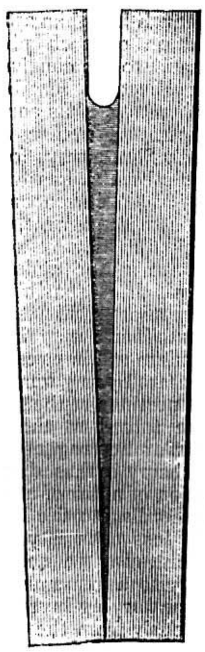


FIG. 1.

work of four and a half centimetre-grammes performed in a space of fifty micro-millimetres.

But now let us vary the circumstances a little. I take the two pieces of rigidified water, and bring them to touch at a pair of corresponding points in the borders of the two surfaces A and B, keeping the rest of these surfaces wide asunder (see Fig. 1). The work done on my hands in this proceeding is infinitesimal. Now, without at all altering the law of attractive force, let a minute film of the rigidified water become fluid all over each of the surfaces A and B: you see exactly what takes place. The pieces of matter I hold in my hands are not the supposed pieces of rigidified water. They are glass, with the surfaces A and B thoroughly clean and wetted all over each with a thin film of water. What you now see taking place is the same as what would take place if things were exactly according to our ideal supposition. Imagine, therefore, that there are really two pieces of water, all rigid, except the thin film on each of the surfaces A and B, which are to be put together. Remember also that the Royal Institution, in which we are met, has been, for the occasion, transported to the centre of the earth so that we are not troubled in any way by gravity. You see we are not troubled by any trickling down of these liquid films—but I must not say *down*, we have no up and down here. You see the liquid film does not trickle along these surfaces towards the table, at least you must imagine that it does not do so. I now turn one or both of these pieces of matter till they are so nearly in contact all over the surfaces A and B, that the whole interstice becomes filled with water. My metrical sense of touch tells me that exactly four and a half centimetre-grammes of work has again been done; this time, however, not by a very great force, through a space of less than fifty micro-millimetres, but by a very gentle force acting throughout the large space of the turning or folding-together motion which you have seen, and now see again. We know, in fact, by the elementary principle of work done in a conservative system, that the work done in the first case of letting the two bodies come together directly, and in the second case of letting them come together by first bringing two points into contact and then folding them together, must be the same, and my metrical sense of touch has merely told me in this particular sense what we all know theoretically must be true in every case of proceeding by different ways to the same end from the same beginning. WILLIAM THOMSON

(*To be continued.*)

THE TOTAL SOLAR ECLIPSE, 1886 *AUGUST* 28–29

THE Eclipse Expedition will leave England on the 29th inst. in the Royal Mail Steamship *Nile*, timed to arrive at Barbados on August 11. We regret to learn that Her Majesty's ship *Canada*, which was told off to assist the Expedition, chiefly by supplying artificers and assistance in camping and in the observations, has been withdrawn on some "diplomatic" service. This is a serious blow to the probabilities of good results.

From data supplied by Mr. Hind, the following details have been computed for the Island of Grenada:—

	Latitude N.	Longitude W.	Commencement of totality G.M.T.	Commencement of totality Local time
	° ′	° ′	h. m. s.	h. m. s.
Levera	12 13·5	61 37	23 17 19	19 10 51
Caliveny	12 0·0	61 43	23 17 14	19 10 22
Point Saline ...	12 0·5	61 48	23 17 10	19 9 58
Fort Frederick.	12 3·0	61 44	23 17 13	19 10 17

	Duration of totality	Sun's Azimuth	Sun's True altitude	Angle from N. point
	m. s.	° ′	° ′	
Levera	3 45	84 12	18 56	87° to W.
Caliveny	3 52	84 6	18 48	73° ,,
Point Saline ...	3 48	84 4	18 42	72° ,,
Fort Frederick.	3 49	84 3	18 46	77° ,,

The sun's altitude and azimuth and the angle from N. point are given for the commencement of totality.

The time of first contact for the middle of the island [assumed lat. 12° 6′·0, long. 61° 43′·0] is 18h. 11m. 55s. local mean time at 77°·0 N. to W. on the sun's limb; and ends at 20h. 20m. 44s. at 105° N. to E. on the limb.

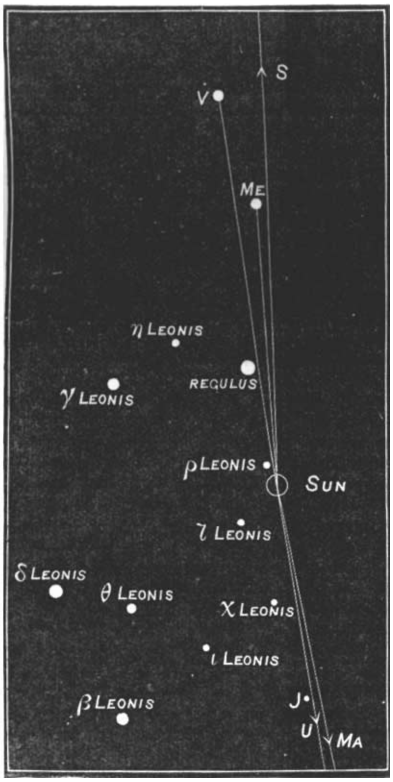
A diagram is given below showing the position of the principal stars and planets at the commencement of totality. The distances of the planets from the sun are very roughly as follows (the positions of Mercury and Venus being shown absolutely, and the directions of the others indicated by arrows):—

Mercury (Me) = 4 | Mars (Ma) = 15
Venus (V) = 6 | Saturn (S) = 12

$\left.\begin{array}{l}\text{Jupiter}\\\text{Uranus}\end{array}\right\}$ almost in conjunction $\left\{\begin{array}{l}\text{(J)}\\\text{(U)}\end{array}\right\} = 8.$

Local mean time of transit of Polaris and δ Ursæ Minoris for Caliveny (Grenada), long. 61° 43′ W.:—

Date 1886		Transit of δ Ursæ Minoris h. m. s.		Transit of Polaris h. m. s.
August 14	...	8 35 46	...	15 43 24
15	...	8 31 49	...	15 39 28
16	...	8 27 52	...	15 35 33
17	...	8 23 55	...	15 31 37
18	...	8 19 58	...	15 27 41
19	...	8 16 1	...	15 23 46
20	...	8 12 4	...	15 19 50
21	...	8 8 7	...	15 15 54
22	...	8 4 11	...	15 11 58
23	...	8 0 14	...	15 8 3
24	...	7 56 17	...	15 4 7
25	...	7 52 20	...	15 0 12
26	...	7 48 23	...	14 56 15
27	...	7 44 26	...	14 52 20
28	...	7 40 30	...	14 48 24
29	...	7 36 33	...	14 44 28



HORIZON

Diagram of configuration of stars and planets during the total solar eclipse, 1886 August 28-29, for Grenada. V = Venus; ME = Mercury; MA = Mars; J = Jupiter; S = Saturn; U = Uranus.

We reprint from *Science* the following paper by Mr. J. Norman Lockyer:—

In order to obtain the greatest amount of assistance from observations of the eclipsed sun, it is necessary to consider in the most general way the condition of solar inquiry at the time the observations are made. If any special work commends itself to those interested in the problem,—work which may be likely to enable us to emphasise or reject existing ideas,—then that work should take precedence of all other.

Next, if the observers are sufficient in number to undertake other work besides this, then that work should be arranged in harmony with previous observations; that is, the old methods of work should be exactly followed, or they should be expanded so that a new series of observations may be begun in the light and in extension of the old ones.

In my opinion, and I only give it for what it is worth, the three burning questions at the present time—questions on which information is required in order that various forms of work may be undertaken to best advantage (besides eclipse-work)—are these:—

(1) The true constitution of the atmosphere of the sun. By this I mean, Are the various series of lines of the same element observed in sunspots, *e.g.*, limited to a certain stratum, each lower stratum being hotter, and therefore simpler in its spectrum, than the one overlying it? and do some of these strata, with their special spectra, exist high in the solar atmosphere, so that the Fraunhofer lines, re-represented in the spectrum of any one substance, are the result of an integration of the various absorptions from the highest stratum to the bottom one? This view is sharply opposed to the other, which affirms that the absorption of the Fraunhofer lines is due to one unique layer at the base of the atmosphere.

I pointed out before the eclipse of 1882 that crucial observations could be made during any eclipse, including the time both before and after totality. I made the observations: they entirely supported the first view, but I do not expect solar inquirers to throw overboard their own views until these observations of mine are confirmed; and I think one of the most important pieces of work to be done during the next eclipse is to see whether these observations can be depended upon or not.

One observer, I think, should repeat the work over the same limited region of the spectrum, near F; another observer should be told off to make similar observations in another part of the spectrum. I have prepared a map of the lines near E, for this purpose, showing those brightened on the passage from the arc to the spark, and those visible alone at the temperature of the oxy-hydrogen flame. Whereas some of the spark lines will be seen seven minutes before and after totality as short, bright lines, some of the others will be seen as thin, long lines just before and after totality. We want to know whether the lines seen at the temperature of the oxy-hydrogen flame will be seen at all, and, if so, to what height they extend.

(2) The second point to which I attach importance is one which can perhaps be left to a large extent to local observers, if the proper apparatus, which may cost very little, be taken out.

With this eclipse in view, I have for the last several months gone over all the recorded information, and have discussed the photographs taken at the various eclipses in connection with the spots observed, especially at those times.

The simple corona observed at a minimum with a considerable equatorial extension (twelve diameters, according to Langley), the complex corona observed at maximum when the spots have been located at latitudes less than 20°, have driven me to the view, which I shall expand on another occasion, that there is a flattened ring round the sun's equator, probably extending far beyond the true atmosphere; that in this ring are collected the products of condensation; and that it is from the surfaces of this ring chiefly that the fall of spot-forming material takes place.

If we take any streamer in mid-latitude, we find, that, while the spots may occur on the equatorial side of it, none are seen on the poleward side. I regard the streamers, therefore, like the metallic prominences, as a sequel to the spot; and there is evidence to suggest that a careful study will enable us to see by what process the reaction of the photosphere and underlying gases produced by the fall of spot-material tends to make the spot-material discharge itself in lower and lower latitudes, as the temperature of the sun's lower atmosphere gets enormously increased.

The observations of Profs. Newcomb and Langley at the minimum of 1878, on the equatorial extension, are among the most remarkable. Prof. Newcomb hid the

moon and 12′ of arc around it at the moment of totality by a disk of wood, carefully shielding his eyes before totality. Prof. Langley observed at a very considerable elevation. It is therefore quite easy to understand why this ring has not been seen or photographed at maximum. At maximum no precautions have been taken to shield the eye; no observations have been made at a considerable elevation; while the fact that the ring, if it exists, consists of cool material, fully explains how it is that the photographic plates have disregarded it.

I would propose, therefore, that the repetition of Prof. Newcomb's observations of 1878 be made an important part in the arrangements of the eclipse for this year. A slight alteration in the method will be necessary, as the ring will be near the vertex and the lowest point of the eclipsed sun.

(3) Another point of the highest importance at the present moment has relation to the existence of carbon. Until Tacchini's observations of 1883, the only trace of carbon in the solar spectrum consisted of ultra-violet flutings. He observed other flutings in the green near the streamers in the eclipse referred to.

Duner's recent work puts it beyond all doubt that stars of Class III. *b* have their visible absorption produced chiefly by carbon vapour.

On any theory of evolution, therefore, we must expect the sun's atmosphere to be composed to a large extent of carbon at some time or other; so that the highest interest attaches to this question in connection with the height in the atmosphere at which the evidence of carbon is observed. The existence of the ultra-violet flutings among the Fraunhofer lines tells nothing absolute about this height, although I inferred, at the time I made the announcement, that it existed at some height in the coronal atmosphere.

These three points, then, are those to which I attach special importance at the present time.

We next come to photographs of the corona. I believe, that, with our present knowledge, the chief thing we have to seek in such photographs is not merely the streamers and their outlines, which we are sure to get anyway, but images on a larger scale; so that in a series of short exposures we may endeavour to get some records which will eventually help us in determining the directions of the lower currents. At present we do not know absolutely whether these flow to or from the poles. My own impression is that the panaches at the poles indicate an upper outflow.

In coming to the photo-spectroscopic observations, I am of opinion, that of the two attacks which I first suggested for the eclipse of 1875, and which have also been used in the last two eclipses of 1882 and 1883, one of them should be discarded, and the whole effort concentrated on the other.

We have learned very much from the use of the prismatic camera,—one of the instruments referred to; but the results obtained by it are not of sufficient accuracy to enable them to be fully utilised. On the other hand, though the slit spectroscope failed in 1875, it succeeded with a brighter corona and more rapid plates in 1882; and, with a proper reference spectrum, every iota of the facts recorded can be at once utilised for laboratory work and subsequent discussion.

On these grounds, then, I would suggest that slit spectroscopes alone be used for photographic registration. I think falling plates should be used, and that the work should begin ten minutes before totality, and continue till ten minutes after; provided the slit be tangential, or nearly so, to the limb.

I may state that arrangements have been made here to take such a series of photographs on the uneclipsed sun; and, with the improved apparatus, I am greatly in hopes that we may get something worth having.

This paper was communicated to the Eclipse Committee, and formed in part the basis for the plan of operations on this occasion, which, as approved by the Committee, are as follows:—

Coronagraph before and after totality.. Camera and prismatic camera during totality	Capt. Darwin
Camera and slit spectroscopes ... ... Integrated intensity of corona	Capt. Abney
Camera and slit spectroscopes	Dr. Schuster
,, ,, ,,	Mr. Maunder
Observations of chromosphere before and after totality, and search for carbon bands during totality	Rev. S. J. Perry
Observations of chromosphere before and after totality, and direction of solar currents during totality	Mr. Turner
Images of corona on large and small scale (2 inches and ¾ inch) with photoheliograph and a 6-inch object-glass by Henry	Mr. Lockyer

Prof. Thorpe replaces Capt. Abney in the above list, and Prof. Tacchini joins the expedition at the invitation of the Royal Society.

NOTES

WE regret to learn of the death of Dr. Abich, the eminent Russian geologist.

MR. DAVID STEPHENSON, of Edinburgh, the well-known civil engineer, died at North Berwick on Saturday last. He was born in 1815, and was a son of Mr. Robert Stephenson, the celebrated engineer of the Bell Rock and other lighthouses. His abilities in his profession were soon recognised. He was appointed at an early age engineer to the Lighthouse Board, and while occupying that position he constructed a number of important lighthouses. In the course of his career he held the office of consulting engineer to the Highland and Agricultural Society and to the Convention of the Royal Burghs, as also engineer to the Board of Fisheries and the Clyde Lighthouse Trust. Mr. Stephenson was a voluminous writer; his more important works included "A Sketch of Civil Engineering in North America," "The Application of Modern Hydrometry to the Practice of Civil Engineering," "Reclamation and Production of Agricultural Land," and "Principles and Practice of Canal and River Engineering." He was an occasional contributor to the columns of NATURE.

THE death is announced of Mr. Charles Mano, seven days after leaving Colon for France, at the age of fifty-five. M. Mano had made various journeys in Spanish America for scientific purposes. In Mexico he discovered several ancient cities which had never before been seen by any European. He was the scientific Commissioner of the Governments of Colombia and of Guatemala.

THE arrangements for the Brighton meeting of the British Medical Association on the 10th, 11th, 12th, and 13th proximo are rapidly approaching completion. In the section of pathology, the new science of bacteriology will receive a good deal of attention, and microscopic photographs of these mysterious organisms will be shown by Dr. Heneage Gibbes and Dr. Crookshank, while the latter will also exhibit the various organisms growing in gelatine, &c.

WE learn from the *Sidereal Messenger* for July that the contract for mounting the 36-inch objective has been awarded by the Lick trustees to Warner and Swasey, of Cleveland, O., for 42,000 dols. The telescope is to be 57 feet long; the diameter of the tube 42 inches. Provisions are made by which it will be possible for the observer at the eye-end of the telescope to command all the possible motions, and these same motions can also be controlled by an observer stationed on a small balcony